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Energy Procedia 16 (2012) 915 – 920

Energy Procedia

2012 International Conference on Future Energy, Environment, and Materials

Hydro-geological Conditions and Mine Inflow Water Forecast of the Western Long Beach in Junggar Coalfield

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Abstract

Gushing water is harmful to underground coal mine safety. Jungar coalfield is the major coal base in the Chinese Midwest, and coal-bearing strata are mainly Shanxi Formation and Taiyuan Formation. Coal seams can be mined in the western long beach are 3#, 5#, 6#, 9#. This paper analyzed regional geological conditions, hydro-geological conditions in the western Long Beach of Jungar coalfield, and water-filled factors, predicted mine water discharge, based on the prediction, and proposed prevention and treatment measures of coal mine water.

Keywords: the western Long Beach of Jungar coalfield; hydro-geological conditions; mine water discharge

1. Introduction

Junggar Coalfield is located in Ordos with syncline northeast of North China platform, and the terrain is from northwest to southeast. Elevation is 1050m ~ 1250m. The average rainfall in many years is 408mm, and the annual total evaporation is up to 1824.7mm ~ 2204.4mm. Yellow River flows through the eastern and the southern edge of the coalfield, which is the largest surface water body around the coalfield, and the minimum basic erosion level of coalfield. The general construction was uplift in east and western depression. Move from south to north, and the monoclinic structure is formed by west tilted. And occurrence is gentle, generally <10 °. Sub-structure is the main-relief folds, and faults developed not

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 doi:10.1016/j.egypro.2012.01.146

well(Shown in Figure 1). Groundwater storage and transport are controlled by the overall structure shape and secondary relief folds [1, 2].

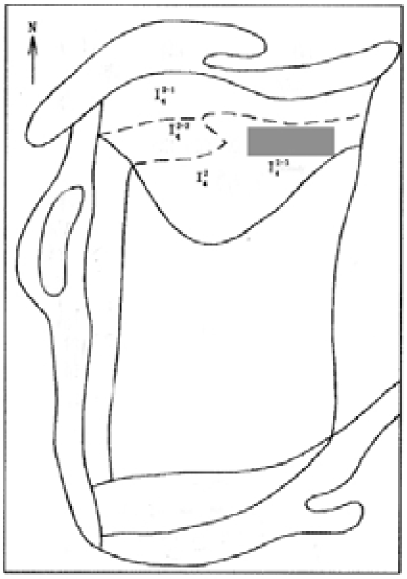

Fig. 1 Sketch map and Study Area (Gray).

Table 1

Age	Rock	Distribution	Thickness	Hydrological characteristics
Quaternary Holocene	Aeolian sand	Kongdui Ditch, Dalu Ditch, Wulanbula	Different with the topography	Permeable but not containing water
Quaternary Holocene	Alluvial layer	Lama Bay, Mashan	Different	With pore water
Quaternary Pleistocene	Loess layer, yellow, brown yellow	Regional distribution	0.00～150.00m	Good water permeability
Tertiary red soil （N_2）	Red clay and loam		Different	Impermeable layer
Cretaceous	Variation in lithology	Northern and northwestern edge of the coalfield	4.00m～20.00m	Uneven rich water
Triassic	Sandstone and mudstone	Southwestern coalfield	More than 165m	Poor rich water
Permian	Sandstone, sandy mudstone, mudstone	Western coalfield	Uncertain	Sandstone porosity, fractured, permeable layer; mudstone as impermeable layer
Carboniferous	Sandstone, mudstone, marl, aluminum soil mudstone	eastern, central and southern coal field	Uncertain	Impermeable layer of coal stable
Ordovician	Limestone	eastern and southern edge of coalfield and the shore of the Yellow River	Uncertain	Karst fissure developed well with better rich water
Cambrian	Silty shale, siltstone, fine sandstone with purple - purple gray	East of the Yellow River	330m	Fractured, good water-rich

2. The Region Lithology and Hydrological Characteristics of the Coalfield

The mined coal layers are $5^{\#}$,$6^{\#}$,$9^{\#}$ in the coalfield.

The region lithology and containing water characteristics in the Coalfield are shown in Table 1. The direct water-filled aquifers in major mining coal seams are Shanxi Formation sandstone fractured aquifers in Permian and Taiyuan Formation sandstone fractured aquifer in Carboniferous. The coalfield is less rainfall with small recharge area and large undulating topography, and valleys are cutting deeply without a good catchment topography[3]. Overall structure is the west-dipping with undulating monocline, which is unfavorable for the enrichment of groundwater storage. The recharge of direct water-filled coal aquifer is extremely small with poor-rich water, and hydro-geological conditions are simple.

3. Hydrological and Geological Conditions of Coalfield

The direct water-filled rock group with coal-water of the mined layer $3^{\#}$, $5^{\#}$, $6^{\#}$, $9^{\#}$ is sandstone fractured aquifer in Shanxi Formation. Taiyuan Formation has mostly changed to sandy mudstone, and can not constitute continuous water-bearing rock group. Shanxi Formation is formed by sandstone, and cracks are developed to vary degrees. Connectivity is better, and the top generally has1 or 2 layers mudstone. Sandy mudstone strata are separated by impermeable layer and the overlying strata. The water depth is 99.98m, head elevation is 1055.47m, permeability coefficient is 0.001m/d, and unit water discharge is 0.00144L/s•m. Sandy mudstone and mudstone layers are the better impermeable in upper and lower stone box, which play a good role in blocking the direct precipitation infiltration recharge water-filled water rock group. The supply source of direct water-filled rock group is from the atmospheric precipitation, which is supplied by coal-bearing strata outcrop or hidden under a layer of overlying loess outcrop. Recharge area is small, the distribution is not concentrated, and very little precipitation determines the supply is limited with poor-rich water.

The fractured of Cambrian, Ordovician limestone, dolomite karst under the coalfield is very uneven, and rich-water is very different. Pressure head elevation of region Cambrian, Ordovician karst fissure is 860m ~ 870m, which is higher 352.68m than the lowest floor elevation of $6^{\#}$. 500m head pressure is equivalent to about 5.0Mpa. Cambrian, Ordovician karst fissure confined aquifer and the coal-bearing strata are separated by stable impermeable layers in Benxi Formation. Rock mechanics testing has shown that uniaxial compressive strength with natural state of sandy mudstone exposing in the lower part of Taiyuan Formation is 42.9Mpa. The intensity values have safety coefficient to barrier 5.0MPa water pressure. It is possible that gushing water could occur in mining when water head elevation is lower than 860～870m in Cambrian, Ordovician limestone karst fissure. Rock group of direct water-filled aquifer in coal mining layers is sandstone water-filled cracks. The unit water discharge is less than 0.1L/s•m and easy dewatering, and hydro-geological conditions are simple.

4. Analysis of Water-filled Deposits

The coalfield is located in the Loess Plateau, which has wide thicken loess, poor consolidation, vertical joint development, large undulating terrain, valleys cutting deep. Precipitation is easy to form flood and concentrated into the Yellow River with little into the ground. There are no surface water bodies, but have the valleys with water. The Yellow River flows through the eastern edge (from the east about 25km) and the southern margin (from the southern boundary about 28km) of the outer coalfield. The bank of the Yellow River around the coalfield cut Cambrian, Ordovician strata, which only contact water power with the above strata. The stable impermeable layers in Benxi Formation are existed between Cambrian, Ordovician karst fissure and coal-bearing strata.

In the recovery area of coal mine, water range is unknown, the series relationship is complex, the volume of water is large with strong acidic and head pressure is great, which is very harmful. To probe hydrocele in the old mine well is the primary mean to prove recoverable water boundaries and keep safe mining.

The main water-filled channels in coalfield are caving zone and fracture zone formed in mining process. The water-filled resource is from the groundwater in sandstone fissures of Shanxi Formation. Direct water-filled aquifers of mined coal seams are fractured sandstone aquifers in Shanxi Formation.

5. Mine Water Discharge Forecasts

Use “Virtual Large Diameter Well “to predict water discharge in roadway system of $6^{\#}$. In the projection, the principles to determine the parameters are as the following[4~6]:

a. Permeability coefficient（K）： Measured and calculated result is $K = 0.001\mathrm{m/d}$.

b. Aquifer thickness（M）： The measured average thickness of the sandstone fractured aquifer in Shanxi Formation is 107.02m.

c. Reference radius of influence（R）： According to the empirical formula: It is measured by $R = 2Sw\sqrt{HK}$ and the measured data R is 2158m.

d. Initial water head value（H）：

The difference between the arithmetic mean of pre-drilling exploration sites in the base elevation of Shanxi Formation and the water level elevation values of the hydrogeology hole in the purposed construction section.

e. Roadway system (“Big Well”), Reference radius（r_0）(shown in Figure 2):

Pre-mining location is rectangle, and according to the reference radius calculated formula, the result is:

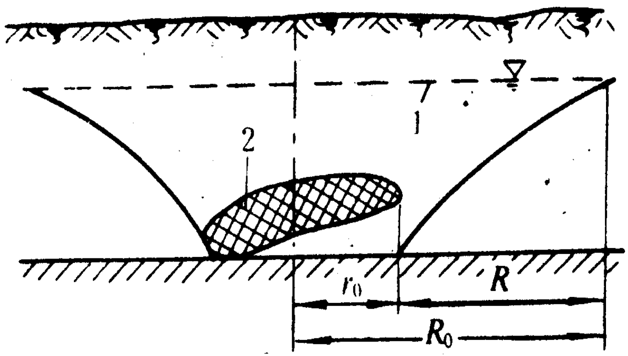

Figure 2 Diagram of Reference radius of influence

$$r_0 = \nu \frac{a+b}{4} = 1.144 \times \frac{8940+2310}{4} = 3217.50\mathrm{m};$$

Suppose if direct water-filled rocks in roadway system of pre-mining sites are homogeneous, isotropic, infinitely aquifer with the same thickness, and suppose if the complex roadway system in pre-mining sites is an area equivalent to the "big well", a formula could get to predict water discharge, when the pressure switch to non-pressure with mathematical model of analytical method with a steady flow[7~10]. The formula is

$$Q = \frac{1.366K[(2H-M)M-h^2]}{\lg Ro/r_0} \quad \text{…………(1)}$$

Dynamic water level: h =0 (The distance is from moving water to the aquifer, $6^{\#}$, dewatering to the bottom of Shanxi Formation, so it is 0);

Groundwater landing radius: $R_O = r_0 + R$=3217.50m＋2158m=5375.50m.

The relationships are shown in Figure 1. The corresponding parameters are put into Equation (1), it is achieved: Q =799m^3/d.

6. Conclusions

Through the analysis of regional geological conditions and hydrological and geological conditions in western Long Beach of Jungar coalfield and the prediction of water discharge in $6^{\#}$, the following conclusions are achieved:

1) The surface water is lack in the coalfield. Direct water-filled aquifer in coal seam is sandstone cracks water rock group in Permian of Shanxi Formation. Precipitation is the main supply source. The overall trend in the coalfield structure is NNW, and tends to SWW, which is not conducive to the enrichment of groundwater.

2) Unit water discharge in water-filled sandstone cracks aquifer is less than 0.1L/s•m. Water discharge in $6^{\#}$ is 799m^3/d, which is the normal water discharge of the final stage of the exploitation in the pre-mining location.

Acknowledgments

This research was supported by National Natural Science Foundation of China (41172015); Education Department of Hebei Province (Z2009121, 2009443, 2010248).

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